

Appendix A

Experimental Protocol and Composition of Exposure Atmospheres

APPENDIX A. EXPERIMENTAL PROTOCOL AND COMPOSITION OF EXPOSURE ATMOSPHERES^a

| Facility/Sponsor | U.S. Environmental Protection Agency | | | | |
|--|--|----------------------|------------------------|---|---------------------------|
| Reference | Bhatnager et al., 1980; Campbell et al., 1980, 1981; Hyde et al., 1985; Moorman et al., 1985; Pepelko et al., 1980b, 1981; Pepelko, 1982b; Pepelko and Peirano, 1983; Plopper et al., 1983 | | | Laurie et al., 1980; Laurie and Boyes, 1980, 1981 | |
| Engine type | Nissan CN 6-33, 3.24 L, 6-cylinder | | | 3.24 L, 6 cylinder | |
| Operating mode | Federal short cycle | | | Federal short cycle | |
| Fuel type | No. 2 diesel | | | No. 2 diesel | |
| Fuel sulfur | 0.15% | | | 0.15% | |
| Exposure regime | 8 h/d, 7 d/week, 124 weeks | | | 8 h/d, 7 d/week, 16 weeks | |
| Exposure conditions | Control | Exhaust - weeks 1-61 | Exhaust - weeks 62-124 | Control | Exhaust |
| Particle conc. (mg/m ³) | 0.00 | 6.34 ± 0.81 | 11.70 ± 0.99 | 0.01 | 5.97 ± 0.17 ^b |
| Particle size | 90% < 1 μm by mass; 50% ≤ 0.3 μm by mass | | | | |
| CO ₂ (%) | 0.04 ± 0.002 | 0.30 ± 0.04 | 0.52 ± 0.04 | 0.05 ± 0.00 ^b | 0.28 ± 0.01 ^b |
| CO (ppm) | 2.20 ± 0.50 | 20.17 ± 3.01 | 33.30 ± 2.94 | 1.86 ± 0.06 ^b | 19.20 ± 0.35 ^b |
| NO ₂ (ppm) | 0.03 ± 0.03 | 2.68 ± 0.80 | 4.37 ± 1.19 | 0.03 ± 0.00 ^b | 2.51 ± 0.10 ^b |
| NO (ppm) | 0.05 ± 0.04 | 11.64 ± 2.34 | 19.39 ± 3.80 | 0.08 ± 0.01 ^b | 11.14 ± 0.43 ^b |
| SO ₂ (ppm) | 0.03 ± 0.02 | 2.12 ± 0.58 | 5.03 ± 1.03 | 0.46 ± 0.02 ^b | 1.82 ± 0.07 ^b |
| SO ₄ ⁻² (μg/m ³) | - | - | - | | |
| Ozone (ppm) | | | | | |
| Aliphatic aldehydes (ppm) | 0.00 | 0.177 ± 0.043 | 0.338 ± 0.057 | | |
| Formaldehyde (ppm) | 0.00 | 0.106 ± 0.029 | 0.251 ± 0.059 | | |
| Acrolein (ppm) | 0.00 | 0.025 ± 0.003 | 0.034 ± 0.009 | | |
| NH ₄ ⁺ | - | - | - | | |
| THC (ppm) | 2.82 ± 0.50 | 7.93 ± 1.42 | 11.02 ± 1.04 | 3.22 ± 0.08 ^b | 7.29 ± 0.11 ^b |
| PAHs | | | | | |
| Benzo(a)pyrene | 15.9 μg/g extract | | | | |
| Benzo(e)pyrene | 28.6 μg/g extract | | | | |
| Benzo(a)anthracene | 53.8 μg/g extract | | | | |
| Benzo(k)fluoranthene | 77.8 μg/g extract (k+b) | | | | |
| Fluoranthene | 155.8 μg/g extract | | | | |
| Pyrene | 198 μg/g extract | | | | |
| Phenanthrene | 145.2 μg/g extract | | | | |
| Chrysene | 71.6 μg/g extract | | | | |
| Perylene | 3.5 μg/g extract | | | | |
| Indeno(1,2,3-Cd) fluoranthene | 10.9 μg/g extract | | | | |
| Indeno(1,2,3-Cd) pyrene | 14.8 μg/g extract | | | | |
| Benzo(ghi)perylene | 21.1 μg/g extract | | | | |

^a All ± are S.D., unless specified otherwise.

^b Standard error of mean values.

APPENDIX A. EXPERIMENTAL PROTOCOL AND COMPOSITION OF EXPOSURE ATMOSPHERES^a

| | | | | |
|--|--------------------------------------|--------------|----------------------|----------------------------|
| Facility/Sponsor | U.S. Environmental Protection Agency | | | |
| Reference | Wiester et al., 1980 | | | Pepelko et al., 1980a |
| Engine type | Nissan CN6-33, 3.24 L, 6 cylinder | | | 3.24 L, 6 cylinder |
| Operating mode | California cycle, modified | | | California cycle, modified |
| Fuel type | No. 2 diesel | | | No. 2 diesel |
| Fuel sulfur | 0.15% | | | |
| Exposure regime | 20 h/d, 7 d/week, 4 weeks | | | 20 h/d, 7 d/week, 4 weeks |
| Exposure conditions | Control | Exhaust | Exhaust - irradiated | Exhaust |
| Particle conc. (mg/m ³) | 0.00 | 6.32 ± 1.31 | 6.83 ± 1.44 | 6.40 ± 0.36 ^b |
| Particle size | | 0.1-1.0 μm | | |
| CO ₂ (%) | 0.04 | 0.261 ± 0.01 | 0.25 ± 0.03 | 0.26 ± 0.008 ^b |
| CO (ppm) | 2.0 | 17.4 ± 2.5 | 16.7 ± 4.0 | 14.61 ± 0.90 ^b |
| NO ₂ (ppm) | 0.07 | 2.3 ± 0.4 | 2.9 ± 0.7 | 2.13 ± 0.09 ^b |
| NO (ppm) | 0.11 | 5.9 ± 0.6 | 5.0 ± 1.2 | 6.13 ± 0.18 ^b |
| SO ₂ (ppm) | 0.0 | 2.1 ± 0.8 | 1.9 ± 0.8 | 2.10 ± 0.21 ^b |
| SO ₄ ⁻² (μg/m ³) | 0.00 | 0.57 ± 0.12 | 0.57 ± 0.13 | 0.577 ± 0.019 ^b |
| Ozone (ppm) | 0.0 | 0.0 | <0.01 | |
| Aliphatic aldehydes (ppm) | | | | |
| Formaldehyde (ppm) | | | | |
| Acrolein (ppm) | | | | |
| NH ₄ ⁺ | | | | |
| THC (ppm) | 0.00 | 31.6 ± 2.3 | 26.1 ± 1.6 | 31.56 ± 1.25 ^b |
| PAHs Benzo(a)pyrene | | | | |
| Nitropyrene | | | | |

^a All ± are S.D., unless specified otherwise.

^b Standard error of mean values.

APPENDIX A. EXPERIMENTAL PROTOCOL AND COMPOSITION OF EXPOSURE ATMOSPHERES^a

| | | | | | | |
|---|--------------------------------------|---------------|----------------------|----------------------------|---------|----------------------|
| Facility/Sponsor | U.S. Environmental Protection Agency | | | | | |
| Reference | Pepelko, 1982a | | | Lee et al., 1978, 1980 | | |
| Engine type | Nissan, 6 cylinder, 3.24 L | | | 3.24 L, 6 cylinder | | |
| Operating mode | California cycle, modified | | | California cycle, modified | | |
| Fuel type | No. 2 diesel | | | No. 2 diesel | | |
| Fuel sulfur | | | | | | |
| Exposure regime | 20 h/d, 7 d/week, 4 weeks | | | 20 h/d, 9 weeks | | |
| Exposure conditions | Control | Exhaust | Exhaust - irradiated | Control | Exhaust | Exhaust - irradiated |
| Particle conc. (mg/m ³) | | 6.40 ± 0.36 | 6.75 ± 0.39 | | 6.32 | 6.83 |
| Particle size (μm) MMD ^b (GSD) ^c | | | | | | |
| CO ₂ (%) | | 0.247 ± 0.003 | 0.244 ± 0.007 | 0.040 | 0.252 | 0.255 |
| CO (ppm) | | 16.9 ± 1.1 | 16.1 ± 1.3 | 2.0 | 15.7 | 15.4 |
| NO ₂ (ppm) | | 2.49 ± 0.18 | 2.76 ± 0.15 | 0.07 | 2.19 | 2.73 |
| NO (ppm) | | 5.71 ± 0.21 | 4.53 ± 0.15 | 0.11 | 5.85 | 4.94 |
| NO _x (ppm) | | | | | | |
| SO ₂ (ppm) | | 2.10 ± 0.21 | 1.86 ± 0.21 | | 2.13 | 1.91 |
| SO ₄ ⁻² (μg/m ³) | | 577 ± 19 | 569 ± 19 | 0.0 | 0.57 | 0.57 |
| O ₃ (%) | | | | | | |
| Ozone (ppm) | | | | | | <0.01 |
| Aliphatic aldehydes | | | | | | |
| Formaldehyde (ppm) | | | | | | |
| Acrolein (ppm) | | | | | | |
| NH ₄ ⁺ | | | | | | |
| Hydrocarbons (ppm) | | 31.6 ± 3.8 | 26.1 ± 3.4 | 2.0 | 15.6 | 15.0 |
| PAHs Benzo(a)pyrene | | | | | | |
| Nitropyrene | | | | | | |

^a All ± are standard errors of weekly means.

^b Mass median diameter.

^c Geometric standard deviation.

APPENDIX A. EXPERIMENTAL PROTOCOL AND COMPOSITION OF EXPOSURE ATMOSPHERES

| | | | | |
|---|---|--|-----------------|---------------------|
| Facility/Sponsor | National Institute for Occupational Safety and Health | | | |
| Reference | Castranova et al., 1985; Fedan et al., 1985; Hahon et al., 1985; Lewis et al., 1986, 1989; Mentnech et al., 1984; Vallyathan et al., 1986 | | | |
| Engine type | Caterpillar 3304, 7 L, 4-cycle | | | |
| Operating mode | 8-mode mining cycle, 60% idling | | | |
| Fuel type | No. 2 diesel | | | |
| Fuel sulfur | 0.34% | | | |
| Exposure regime | 7 h/d, 5 d/week, 104 weeks | | | |
| Exposure conditions | Control | Exhaust | Coal dust | Exhaust + coal dust |
| Particle conc. (mg/m ³) | | | 4.98 ± 0.82 | 3.23 ± 0.60 |
| Respirable particles ^b (mg/m ³) | | 1.95 ± 0.25 | 2.00 ± 0.41 | 2.02 ± 0.30 |
| Particle size (μm) MMD ^c (GSD) ^d | | 0.23 (± 2.5) ^e 0.36 (± 2.0) ^f | | |
| CO ₂ (%) | 0.08 ± 0.02 | 0.20 ± 0.06 | 0.09 ± 0.05 | 0.20 ± 0.07 |
| CO (ppm) | 2.2 ± 0.9 | 11.5 ± 3.1 | 2.2 ± 0.9 | 10.9 ± 2.8 |
| NO ₂ (ppm) | 0.06 ± 0.04 | 1.5 ± 0.5 | 0.06 ± 0.05 | 1.6 ± 0.5 |
| NO (ppm) | 0.08 ± 0.14 | 8.7 ± 3.6 | 0.08 ± 0.29 | 8.3 ± 3.2 |
| SO ₂ (ppm) | | 0.81 ± 0.38 | 0.01 ± 0.07 | 0.61 ± 0.29 |
| SO ₄ ⁻² (μg/m ³) | | 29.0 ± 24.9 | 16.8 ± 17.9 | 42.3 ± 33.8 |
| Aliphatic aldehydes (ppm) | 0.02 ± 0.01 | 0.12 ± 0.06 | 0.02 ± 0.01 | 0.12 ± 0.05 |
| Formaldehyde (ppm) | 0.0076 ± 0.0035 | 0.0383 ± 0.0230 | 0.0074 ± 0.0041 | 0.0374 ± 0.0266 |
| Acetaldehyde (ppm) | 0.0015 ± 0.0035 | 0.0387 ± 0.0153 | 0.0009 ± 0.0025 | 0.0377 ± 0.014 |
| Acrolein (ppm) | 0.0030 ± 0.0033 | 0.0602 ± 0.0245 | 0.0062 ± 0.0047 | 0.0578 ± 0.0205 |
| NH ₃ (ppm) | 0.52 ± 0.28 | 0.64 ± 0.71 | 0.57 ± 0.52 | 0.48 ± 0.55 |
| NH ₄ ⁺ (ppm) | | 0.027 ± 0.0307 | 0.0065 ± 0.0143 | 0.0165 ± 0.0233 |
| THC (ppm) | 4.1 ± 1.9 | 7.5 ± 2.2 (cold) | | 7.4 ± 2.0 (cold) |
| PAH (μg/m ³) Benzo(a)pyrene | | 13.5 ± 6.8 | | 10.2 ± 6.5 |
| Benzo(a)anthracene | | 19.6 ± 9.9 | 3.2 ± 2.2 | 11.2 ± 5.2 |
| Benzo(k)fluoranthene | | 5.6 ± 2.3 | | 3.6 ± 2.4 |
| Fluoranthene | | 139.3 ± 98.1 | 26.5 ± 11.5 | 67.5 ± 52.4 |
| Pyrene | | 123.4 ± 72.2 | 32.3 ± 15.1 | 60.0 ± 36.6 |

^a All ± are S.D., unless specified otherwise.

^b < 7 μm.

^c Mass median diameter.

^d Geometric standard deviation.

^e Electrical aerosol size analyzer.

^f Scanning electron microscope.

APPENDIX A. EXPERIMENTAL PROTOCOL AND COMPOSITION OF EXPOSURE ATMOSPHERES^a

| | | | | | | | | |
|---|---|---------|-----------|---------------------|---------------------------------------|-------------|--------------|---------------------|
| Facility/Sponsor | National Institute for Occupational Safety and Health | | | | | | | |
| Reference | Green et al., 1983; Rabovsky et al., 1986 | | | | Rabovsky et al., 1984 | | | |
| Engine type | Caterpillar, 7 L, 4 cylinder, 4-cycle | | | | Caterpillar, 7 L, 4 cylinder, 4-cycle | | | |
| Operating mode | 8-mode mining cycle, 60% idling | | | | 8-mode mining cycle, 60% idling | | | |
| Fuel type | No. 2 diesel | | | | No. 2 diesel | | | |
| Fuel sulfur | < 0.5% | | | | | | | |
| Exposure regime | 7 h/d, 5 d/week, 12 mo. | | | | 7 h/d, 5 d/week, 24 mo. | | | |
| Exposure conditions | Control | Exhaust | Coal dust | Exhaust + coal dust | Control | Exhaust | Coal dust | Exhaust + coal dust |
| Particle conc. (mg/m ³) | | 2 | 5 | 3 | | | | |
| Respirable particles ^b (mg/m ³) | | 2.01 | 1.97 | 2.08 | | 1.9 ± 0.3 | 2.1 ± 0.4 | 2.0 ± 0.3 |
| Particle size (μm) MMD ^c (GSD) ^d | | | | | | | | |
| CO ₂ (%) | 0.08 | 0.21 | 0.09 | 0.20 | 0.07 ± 0.02 | 0.16 ± 0.04 | 0.08 ± 0.04 | 0.17 ± 0.06 |
| CO (ppm) | 2.3 | 12.7 | 2.4 | 11.1 | 2.0 ± 0.9 | 10.5 ± 2.3 | 2.1 ± 0.8 | 10.3 ± 2.0 |
| NO ₂ (ppm) | 0.04 | 1.6 | 0.04 | 1.3 | 0.06 ± 0.04 | 1.5 ± 0.5 | 0.07 ± 0.05 | 1.5 ± 0.05 |
| NO (ppm) | 0.07 | 9.7 | 0.08 | 1.3 | 0.08 ± 0.13 | 7.8 ± 3.1 | 0.08 ± 0.28 | 7.6 ± 2.8 |
| SO ₂ (ppm) | 0.01 | 0.83 | | 0.56 | | 0.6 ± 0.4 | 0.003 ± 0.05 | 0.5 ± 0.3 |
| SO ₄ ⁻² (μg/m ³) | | | | | | | | |
| Aliphatic aldehydes | | | | | | | | |
| Formaldehyde (ppm) | | | | | | | | |
| Acetaldehyde (ppm) | | | | | | | | |
| Acrolein (ppm) | | | | | | | | |
| NH ₃ (ppm) | 0.63 | 1.13 | 0.83 | 0.54 | 0.5 ± 0.6 | 0.6 ± 0.8 | 0.6 ± 0.7 | 0.4 ± 0.3 |
| NH ₄ ⁺ (ppm) | | | | | | | | |
| THC (ppm) | | | | | | | | |
| PAH (μg/m ³) Benzo(a)pyrene | | | | | | | | |
| Nitropyrene | | | | | | | | |

^a All ± are S.D. unless specified otherwise.

^b < 7 μm.

^c Mass median diameter

^d Geometric standard deviation.

**APPENDIX A. EXPERIMENTAL PROTOCOL AND COMPOSITION OF EXPOSURE
ATMOSPHERES^a**

| | | | | | | |
|--|---|---------------|---------------|---------------|-----------------------------|---------------|
| Facility/Sponsor | General Motors Research Lab | | | | | |
| Reference | Barnhart et al., 1981, 1982; Chaudhari et al., 1980, 1981; Chaudhari and Dutta, 1982; Chen and Vostal, 1981; Dziedzic, 1981; Eskelson et al., 1981; Penney et al., 1981; Misiorowski et al., 1980, 1981; Navarro et al., 1981; Schneider and Felt, 1981; Schreck et al., 1980, 1981; Strom, 1984; Vostal et al., 1981; Wallace et al., 1987; White and Garg, 1981 | | | | Gross, 1981 | |
| Engine type | 1978 350D Oldsmobile, 5.7 L, 4-cycle | | | | 5.7 L | |
| Operating mode | 1350 rpm, 96 N·m | | | | 1350 rpm, 96 N·m | |
| Fuel type | Amoco type 2D | | | | Amoco type 2D | |
| Fuel sulfur | 0.27% | | | | 0.27% | |
| Exposure regime | 20 h/d, 5½ d/week, 104 weeks | | | | 20 h/d, 5½ d/week, 87 weeks | |
| Exposure conditions | Control | Exhaust | Exhaust | Exhaust | Control | Exhaust |
| Particle conc. (mg/m ³) | 0.007 ± 0.009 | 0.258 ± 0.087 | 0.796 ± 0.228 | 1.533 ± 0.346 | 0.007 ± 0.009 | 1.533 ± 0.346 |
| Particle size (μm) MMD ^b (GSD) | | 0.19 | | | 0.2 | |
| CO ₂ (%) | | | | | | |
| CO (mg/m ³) | 2.2 ± 0.6 | 3.4 ± 0.8 | 5.3 ± 0.9 | 7.9 ± 2.1 | 1.9 | 7 |
| NO ₂ (ppm) | | | | | 0.5 | |
| NO (ppm) | | | | | 6.7 | |
| NO _x (mg/m ³) | 0.05 | 2.1 ± 0.6 | 5.0 ± 1.2 | 9.2 ± 1.6 | <0.04 | 7.2 |
| Sulfur (mg/m ³) | | | | | 1.4 | |
| SO ₂ (ppm) | | | | | | |
| Aliphatic aldehydes | | | | | | |
| Formaldehyde (ppm) | | | | | | |
| Acrolein (ppm) | | | | | | |
| NH ₄ ⁺ | | | | | | |
| THC (ppm) | | | | | | |
| PAHs Benzo(a)pyrene | | | | | | |
| Nitropyrene | | | | | | |

^a All ± are S.D., unless specified otherwise.

^b Mass median diameter.

APPENDIX A. EXPERIMENTAL PROTOCOL AND COMPOSITION OF EXPOSURE ATMOSPHERES^a

| | | | | |
|---|---|--|--|--|
| Facility/Sponsor | Inhalation Toxicology Research Institute | | | |
| Reference | Bice et al., 1985; Cheng et al., 1984; Henderson et al., 1983, 1985, 1988; Mauderly et al., 1983, 1984, 1987a, b, 1988; McClellan et al., 1986; Wolf et al., 1987 | | | |
| Engine type | 1980 Oldsmobile V8, 5.7 L | | | |
| Operating mode | Federal Test Procedure, urban driving cycle | | | |
| Fuel type | Phillips No. 2 diesel | | | |
| Fuel sulfur | 0.34% | | | |
| Exposure regime | 7 h/d, 5 d/week, 130 weeks | | | |
| Exposure conditions | Control | Exhaust | Exhaust | Exhaust |
| Particle conc. (mg/m ³) | 0.013 ± 0.006 | 0.353 ± 0.071 | 3.469 ± 0.447 | 7.082 ± 0.808 |
| Particle size (μm) MMD ^b (GSD) ^c | | 0.183 ± 0.04 (4.8 ± 0.28) ^d 0.262 ± 0.06 (4.2 ± 0.24) ^e | 0.184 ± 0.02 (5.3 ± 0.64) ^d 0.249 ± 0.03 (4.5 ± 0.54) ^e | 0.213 ± 0.06 (4.7 ± 0.94) ^d 0.234 ± 0.06 (4.4 ± 0.88) ^e |
| CO ₂ (%) | 0.2005 ± 0.0390 | 0.2284 ± 0.0371 | 0.4355 ± 0.0590 | 0.6643 ± 0.1320 |
| CO (ppm) | 1.0 ± 0.7 | 2.9 ± 1.0 | 16.5 ± 7.1 | 29.7 ± 12.9 |
| NO _x (ppm) | 0 | 0.05 ± 0.09 | 0.34 ± 0.22 | 0.68 ± 0.48 |
| NO (ppm) | 0 | 0.7 ± 0.3 | 5.7 ± 1.5 | 10.0 ± 2.6 |
| SO _x (ppm) | | | | |
| SO ₄ ⁻² (μg/m ³) | | | | |
| Aliphatic aldehydes (ppm) | | | | |
| Formaldehyde (ppm) | | | | |
| Acrolein (ppm) | | | | |
| Ammonia (ppm) | 1.1 ± 3.0 | 1.4 ± 1.3 | 0.9 ± 0.9 | 0.7 ± 0.6 |
| Hydrocarbons (ppm) | 2.6 ± 0.6 | 3.8 ± 0.9 | 8.7 ± 5.2 | 13.4 ± 8.3 |
| PAHs Benzo(a)pyrene | | | | |
| Nitropyrene | | | | |

^a All ± are S.D. unless specified otherwise; data for particles through 30 mo.; data for gases from 35th week through 30 mo.

^b Mass median diameter.

^c Geometric standard deviation.

^d Lovelace multiple jet impactor, mass median aerodynamic diameter.

^e Impactor/parallel flow diffusion battery, mass median diameter.

APPENDIX A. EXPERIMENTAL PROTOCOL AND COMPOSITION OF EXPOSURE ATMOSPHERES^a

| | | | | | | | | |
|---|---|------------------|------------------|------------------|---------------------------------------|------------------|------------------|------------------|
| Facility/Sponsor | Inhalation Toxicology Research Institute | | | | | | | |
| Reference | Inhalation Toxicology Research Institute - Annual Report, 1980 | | | | Mauderly et al., 1981 ^b | | | |
| Engine type | 1980 GM, 5.7 L | | | | 1980 GM, 5.7 L | | | |
| Operating mode | California 7-mode urban cycle | | | | California 7-mode urban cycle | | | |
| Fuel type | Phillips No. 2 diesel | | | | Phillips No. 2 diesel | | | |
| Fuel sulfur | | | | | | | | |
| Exposure regime | 7 h/d, 5 d/week, 12 weeks | | | | 7 h/d, 5 d/week, 19 weeks | | | |
| Exposure conditions | Control | Exhaust | Exhaust | Exhaust | Control | Exhaust | Exhaust | Exhaust |
| Particle conc. (mg/m ³) | 0.039 ± 0.020 | 0.230 ± 0.073 | 1.030 ± 0.340 | 4.260 ± 1.110 | 0.050 ± 0.024 | 0.210 ± 0.070 | 1.020 ± 0.350 | 4.380 ± 1.160 |
| Particle size (μm) MMD ^c (GSD) ^d | | | | | | | | |
| CO ₂ (%) | | | | 0.2080 ± 0.04 | | | | |
| CO (ppm) | 1.1 ± 0.6 | 1.5 ± 0.6 | 3.7 ± 1.1 | 11.5 ± 2.6 | | | | |
| NO ₂ (ppm) | | | | 0.4 ± 0.4 | | | | |
| NO (ppm) | | | | 0.80 ± 0.25 | | | | |
| NO _x (ppm) | | | | | | | | |
| SO ₂ (ppm) | | | | | | | | |
| SO ₄ ⁻² (μg/m ³) | | | | | | | | |
| O ₃ (%) | | | | | | | | |
| Ozone (ppb) | | | | 14.6 ± 3.1 | | | | |
| Aliphatic aldehydes | | | | | | | | |
| Formaldehyde (ppm) | | | | | | | | |
| Acrolein (ppm) | | | | | | | | |
| Ammonia | 2.8 ± 0.7 | 3.2 ± 0.8 | 2.9 ± 0.9 | 2.5 ± 0.7 | | | | |
| Hydrocarbons (ppm) | | | | 4.0 ± 0.8 | | | | |
| HTHC (ppm) | | | | | | | | |
| PAHs | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | |
| Nitropyrene | | | | | | | | |

^a All ± are S.D. unless specified otherwise.

^b Concentrations of gaseous components reported to be proportional to these in 12-week study.

^c Mass median diameter.

^d Geometric standard deviation.

| APPENDIX A. EXPERIMENTAL PROTOCOL AND COMPOSITION OF EXPOSURE ATMOSPHERES ^a | | | | | | | | | | |
|--|---|---------|---------|---------------------|--------------------------|--|---------|---------|--------------------------|--------------------------|
| Facility/Sponsor | Japan Automobile Research Institute Inc. (Health Effects Research Program - HERP) | | | | | | | | | |
| Reference | HERP 1988; Ishinishi et al., 1986; Ishinishi et al., 1989 | | | | | | | | | |
| Engine type | Light duty, 1.8 L, 4-cylinder, swirl chamber | | | | | Heavy duty, 11 L, 6-cylinder, direct injection | | | | |
| Operating mode | 1700 rpm, eddy current dynamometer | | | | | 1200 rpm, eddy current dynamometer | | | | |
| Fuel type | Nippon Oil Co JIS No. 1 or 2 diesel | | | | | Nippon Oil Co JIS No. 1 or 2 diesel | | | | |
| Fuel sulfur | 0.41% | | | | | 0.41% | | | | |
| Exposure regime | 16 h/d, 6 d/week, 30 mo. | | | | | 16 h/d, 6 d/week, 30 mo. | | | | |
| Exposure conditions | Control | Exhaust | Exhaust | Exhaust | Exhaust | Control | Exhaust | Exhaust | Exhaust | |
| Particle conc. (mg/m ³) | 0.003 | 0.11 | 0.41 | 1.08 | 2.32 | 0.002 | 0.46 | 0.96 | 1.84 | 3.72 |
| Particle size (μm) MMD ^b (GSD) ^c | | | | 0.19 (2.37-2.71) | 0.21-0.22 (2.23-2.93) | | | | 0.20-0.23 (2.73-3.07) | 0.25-0.28 (2.75-3.18) |
| CO ₂ (%) | 0.026 | 0.050 | 0.105 | 0.219 | 0.418 | 0.035 | 0.084 | 0.140 | 0.215 | 0.360 |
| CO (ppm) | 0.80 | 1.23 | 2.12 | 3.96 | 7.10 | 0.63 | 2.65 | 4.85 | 7.75 | 12.91 |
| NO _x (ppm) | 0.011 | 0.08 | 0.26 | 0.70 | 1.41 | 0.021 | 0.46 | 1.02 | 1.68 | 3.00 |
| NO (ppm) | 0.033 | 1.16 | 3.81 | 9.44 | 18.93 | 0.042 | 5.71 | 12.11 | 19.99 | 34.45 |
| NO _x (ppm) | 0.044 | 1.24 | 4.06 | 10.14 | 20.34 | 0.061 | 6.17 | 13.13 | 21.67 | 37.45 |
| SO ₂ (ppm) | 0.06 | 0.38 | 1.06 | 2.42 | 4.70 | 0.06 | 0.98 | 1.79 | 2.82 | 4.57 |
| SO ₄ ⁻² (μg/m ³) | 0.41 | 18.8 | 62.4 | 151 | 315 | 0.49 | 62.9 | 111 | 198 | 361 |
| O ₃ (%) | 20.8 | 20.8 | 20.7 | 20.5 | 20.3 | 20.8 | 20.8 | 20.7 | 20.6 | 20.4 |
| Aliphatic aldehydes | | | | | | | | | | |
| Formaldehyde (ppm) | 0.002 | 0.01 | 0.03 | 0.07 | 0.13 | 0.003 | 0.05 | 0.11 | 0.18 | 0.29 |
| Acrolein (ppm) | | | | | | | | | | |
| NH ₄ ⁺ | | | | | | | | | | |
| LTHC (ppm) | 2.17 | 2.27 | 2.51 | 2.87 | 3.57 | 3.50 | 4.27 | 5.16 | 5.90 | 7.62 |
| HTHC (ppm) | 2.20 | 2.44 | 2.93 | 3.82 | 5.49 | 2.43 | 4.63 | 7.15 | 9.94 | 15.65 |
| PAHs (ng/m ³) Benzo(a)pyrene | | | | | 5.3 ± 10.6 | | | | | 7.5 ± 3.2 |
| Benzo(k)fluoranthene | | | | | 5.4 ± 7.7 | | | | | 6.0 ± 3.0 |
| Benzo(ghi)perylene | | | | | 2.7 ± 3.9 | | | | | 8.9 ± 2.5 |
| 1-Nitropyrene | | | | | 46.6 ± 44.0 | | | | | 43.4 ± 9.8 |

^a All ± are S.D., unless specified otherwise.

^b Mass median diameter.

^c Geometric standard deviation.

**APPENDIX A. EXPERIMENTAL PROTOCOL AND COMPOSITION OF EXPOSURE
ATMOSPHERES^a**

| | | | | | |
|--|---|-------------------|---------|-------------------|--------------------------|
| Facility/Sponsor | Japan Automobile Research Institute Inc. (Health Effects Research Program - HERP) | | | | |
| Reference | HERP, 1988; Ishinishi et al., 1986; Ishinishi et al., 1989 | | | | |
| Engine type | Heavy duty, 11 L, 6-cylinder, direct injection | | | | |
| Operating mode | 1200 rpm, eddy current dynamometer | | | | |
| Fuel type | Nippon Oil Co JIS No. 1 or 2 | | | | |
| Fuel sulfur | 0.41% | | | | |
| Exposure regime | 16 h/d, 6 d/week, 30 mo. | | | | |
| Exposure conditions | Control | Exhaust, filtered | Exhaust | Exhaust, filtered | Exhaust |
| Particle conc. (mg/m ³) | 0.004 | 0.005 | 0.39 | 0.019 | 2.99 |
| Particle size (μm) MMD ^b (GSD) ^c | | | | | 0.31-0.35 (2.58-2.83) |
| CO ₂ (%) | 0.068 | 0.083 | 0.084 | 0.391 | 0.412 |
| CO (ppm) | 0.06 | 2.54 | 2.50 | 13.00 | 12.90 |
| NO _x (ppm) | 0.024 | 0.42 | 0.44 | 3.96 | 4.95 |
| NO (ppm) | 0.040 | 5.16 | 5.37 | 32.81 | 31.50 |
| NO _x (ppm) | 0.062 | 5.58 | 5.81 | 36.76 | 36.45 |
| SO ₂ (ppm) | 0.03 | 0.96 | 0.98 | 4.50 | 4.03 |
| SO ₄ ⁻² ($\mu\text{g}/\text{m}^3$) | 0.35 | 1.43 | 57.7 | 1.61 | 358 |
| O ₂ (%) | 20.8 | 20.7 | 20.7 | 20.4 | 20.3 |
| Aliphatic aldehydes | | | | | |
| Formaldehyde (ppm) | 0.003 | 0.04 | 0.04 | 0.24 | 0.20 |
| Acrolein (ppm) | | | | | |
| NH ₄ ⁺ | | | | | |
| LTHC (ppm) | 3.62 | 4.43 | 4.41 | 7.79 | 7.68 |
| HTHC (ppm) | 2.38 | 3.74 | 4.53 | 12.68 | 13.79 |
| PAHs Benzo(a)pyrene | | | | | |
| Nitropyrene | | | | | |

^a All ± are S.D. unless specified otherwise.

^b Mass median diameter.

^c Geometric standard deviation.

APPENDIX A. EXPERIMENTAL PROTOCOL AND COMPOSITION OF EXPOSURE ATMOSPHERES

| | | | | | |
|--|--|-------------------|-------------------------------------|---------------------------|-------------------|
| Facility/Sponsor | Fraunhofer Institut fur Toxikologie und Aerosolforschung | | | | |
| Reference | Heinrich et al. 1982 | | Heinrich et al., 1986; Stober, 1986 | | |
| Engine type | 2.4 L | | 1.6 L | | |
| Operating mode | Constant load of 16kW, 2400 rpm | | FTP (1972) | | |
| Fuel type | European reference fuel | | European reference fuel | | |
| Fuel sulfur | 0.36% | | 0.36% | | |
| Exposure regime | 7-8 h/d, 5 d/week, 104 weeks | | 19 h/d, 6 d/week, 120-140 weeks | | |
| Exposure conditions | Exhaust | Exhaust, filtered | Control | Exhaust | Exhaust, filtered |
| Particle conc. (mg/m ³) | 3.9 ± 0.5 | | | 4.24 ± 1.42 | |
| Particle size (μm) MMD ^b | 0.1 | | | 0.35 ± 0.10 | |
| CO ₂ (%) | 0.54 ± 0.15 | 0.52 ± 0.13 | 0.10 ± 0.01 | 0.38 ± 0.05 | 0.35 ± 0.05 |
| CO (ppm) | 18.5 ± 4.9 | 18.0 ± 4.4 | 0.16 ± 0.27 | 12.5 ± 2.18 | 11.1 ± 1.92 |
| NO ₂ (ppm) | 1.2 ± 1.7 | 1.0 ± 1.5 | - | 1.5 ± 0.33 | 1.2 ± 0.26 |
| NO (ppm) | 16.5 ± 5.8 | 17.2 ± 5.9 | - | 10.0 ± 2.09 | 8.7 ± 1.84 |
| NO _x (ppm) | 18.6 ± 5.8 | 19.2 ± 6.1 | - | 11.4 ± 2.09 | 9.9 ± 1.80 |
| SO ₂ (ppm) | 3.1 ± 1.8 | 2.8 ± 1.7 | - | 1.12 ± 0.89 | 1.02 ± 0.62 |
| SO ₄ ⁻² (μg/m ³) | | | | | |
| O ₂ (vol%) | 19.5 ± 0.6 | 20.0 ± 0.7 | | | |
| Aliphatic aldehydes | | | | | |
| Formaldehyde (ppm) | | | | | |
| Acrolein (ppm) | | | | | |
| NH ₄ ⁺ | | | | | |
| THC (ppm) | 9.3 ± 4.6 | 7.9 ± 3.3 | 3.5 ± 0.29 | 5.5 ± 0.69 | 5.2 ± 0.65 |
| CH ₄ (ppm) | 3.0 ± 2.2 | 2.6 ± 1.8 | 2.3 ± 0.17 | 2.6 ± 0.19 | 2.4 ± 0.20 |
| PAHs (μg/g part.) | | | | | |
| Benzo(a)pyrene | 7.0 | | | 3 (13 ng/m ³) | |
| Benzo(e)pyrene | 14.1 | | | - (21 ng/m ³) | |
| Benz(a)anthracene | 9.8 | | | | |
| Fluoranthene | 134.6 | | | | |
| Pyrene | 65.8 | | | | |
| Benzo(a)fluoranthene | 5.4 | | | | |
| Benzo(b)fluoranthene | 5.3 | | | - (51 ng/m ³) | |
| Benzo(ghi)perylene | 21.4 | | | | |
| Chrysene | 25.7 | | | | |

^a All ± are S.D. unless specified otherwise.

^b Mass median diameter.

APPENDIX A. EXPERIMENTAL PROTOCOL AND COMPOSITION OF EXPOSURE ATMOSPHERES

| Facility/Sponsor | Fraunhofer Institut fur Toxikologie und Aerosolforschung | | | | | | |
|--|--|---------|----------------------|---------|----------------------|---------|----------------------|
| Reference | Heinrich et al., 1979; Meiss et al., 1981 | | | | | | |
| Engine type | 2.4 L | | | | | | |
| Operating mode | Constant load of 16 kW, 2400 rpm | | | | | | |
| Fuel type | European reference fuel | | | | | | |
| Fuel sulfur | 0.36% | | | | | | |
| Exposure regime | 7-8 h/d, 5 d/week, 5 mo. | | | | | | |
| Exposure conditions | Control | Exhaust | Exhaust, filtered | Exhaust | Exhaust, filtered | Exhaust | Exhaust, filtered |
| Particle conc. (mg/m ³) | | 4 | | 11 | | 17 | |
| Particle size (μm) ^b | | 0.1 | | 0.1 | | 0.1 | |
| CO ₂ (%) | 0.1 | 0.5 | 0.5 | 0.9 | 0.95 | 1.4 | 1.6 |
| CO (ppm) | <1 | 11 | 11 | 25 | 27 | 42 | 45 |
| NO ₂ (ppm) | | 0.6 | 0.5 | 1.5 | 1.3 | 2.6 | 2.7 |
| NO (ppm) | | 25 | 22 | 43 | 43 | 75 | 68 |
| NO _x (ppm) | | 26 | 23 | 45 | 44 | 78 | 71 |
| SO ₂ (ppm) | <1 | 3 | 4 | 8 | 8 | 13 | 12 |
| SO ₄ ⁻² (μg/m ³) | | | | | | | |
| O ₂ (vol%) | | | | | | | |
| Aliphatic aldehydes | | | | | | | |
| Formaldehyde (ppm) | | | | | | | |
| Acrolein (ppm) | | | | | | | |
| NH ₄ ⁺ | | | | | | | |
| THC (ppm) | 6 | 8 | 8 | 11 | 12 | 13 | 13 |
| CH ₄ (ppm) | | 5 | 5 | 5 | 5 | 5 | 5 |
| PAHs Benzo(a)pyrene | | | | | | | |
| Nitropyrene | | | | | | | |

^a Values estimated from graphically depicted data.

^b Aerodynamic diameter of the modal peak of the particle mass distribution.

APPENDIX A. EXPERIMENTAL PROTOCOL AND COMPOSITION OF EXPOSURE ATMOSPHERES^a

| | | | | |
|--|---|------------------------------|----------------------------|-------------------------------|
| Facility/Sponsor | Southwest Research Institute | | | |
| Reference | Kaplan et al., 1983; White et al., 1983 | | | Kaplan et al., 1982 |
| Engine type | 5.7 L | | | 5.7 L |
| Operating mode | Steady state, 1347 rpm, equivalent to constant 40 mph | | | Steady state, 40 mph |
| Fuel type | Emissions 2D | | | |
| Fuel sulfur | 0.23-0.24% | | | |
| Exposure regime | 20 h/d, 7 d/week, 65 weeks | | | 20 h/d, 7 d/week, 12-13 weeks |
| Exposure conditions | Control | Exhaust | Exhaust | Exhaust |
| Particle conc. (mg/m ³) | 0.01 ± 0.009 | 0.242 ± 0.049 | 0.735 ± 0.084 | 1.500 ± 0.136 |
| Particle size (μm) | | 88-93% < 1.0 79-85% < 0.5 | 88-94% <1.0 76-84% <0.5 | 91-94% <1.0 81-85% <0.5 |
| CO ₂ (%) | 0.0649 ± 0.0020 | 0.0781 ± 0.0028 | 0.1026 ± 0.0043 | 0.1355 ± 0.0062 |
| CO (ppm) | 5.81 ± 0.2 | 6.39 ± 0.3 | 7.43 ± 0.3 | 9.40 ± 0.5 |
| NO ₂ (ppm) | | | | |
| NO (ppm) | 0 | 0.56 | 1.69 | 3.42 |
| NO _x (ppm) | 0.05 ± 0.0 | 0.65 ± 0.1 | 1.85 ± 0.2 | 3.73 ± 0.4 |
| SO ₂ (ppm) | | | | |
| SO ₄ ⁻² (μg/m ³) | | | | |
| O ₂ (%) | | | | |
| Aliphatic aldehydes | | | | |
| Formaldehyde (ppm) | | | | |
| Acrolein (ppm) | | | | |
| NH ₄ ⁺ | | | | |
| Hydrocarbons (ppm) | 3.43 ± 0.2 | 3.76 ± 0.3 | 4.31 ± 0.3 | 4.99 ± 0.3 |
| <u>PAHs</u> | | | | |
| Benzo(a)pyrene | | | | |
| Nitropyrene | | | | |

^a All ± are S.D. unless specified otherwise.

APPENDIX A. EXPERIMENTAL PROTOCOL AND COMPOSITION OF EXPOSURE ATMOSPHERES

| | | | | | | | | |
|---|---|---------|---------|--------------------------|--------------------------|-------------------------------------|--------------------------|--------------------------|
| Facility/Sponsor | Battelle-Geneva Research Center | | | | | Japan Anti-Tuberculosis Association | | |
| Reference | Brightwell et al., 1986; Bernstein et al., 1984 | | | | | Iwai et al., 1986 | | |
| Engine type | 1.5 L | | | | | 2.37 L | | |
| Operating mode | FTP - 1972 | | | | | Steady state, 1000 rpm | | |
| Fuel type | | | | | | | | |
| Fuel sulfur | | | | | | | | |
| Exposure regime | 16 h/d, 5 d/week, 104 weeks | | | | | 8 h/d, 7 d/week, 96 weeks | | |
| Exposure conditions | Control | Exhaust | Exhaust | Exhaust | Exhaust, filtered | Control | Exhaust, filtered | Exhaust |
| Particle conc. (mg/m ³) | | 0.7 | 2.2 | 6.6 | | | | 4.9 ± 1.6 |
| Particle size (μm) MMD ^b (GSD) ^c | | | | | | | | |
| CO ₂ (%) | | | | 0.46 ± 0.03 ^e | 0.47 ± 0.03 ^e | | | |
| CO (ppm) | 1 ± 3 | | | 32 ± 11 | 32 ± 11 | | 7.0 ± 1.4 ^d | 7.0 ± 1.4 ^d |
| NO _x (ppm) | | | | | | | 1.8 ± 1.8 ^d | 1.8 ± 1.8 ^d |
| NO (ppm) | | | | 5.8 ± 2.0 ^f | 6.0 ± 2.0 ^f | | | |
| NO _x (ppm) | 0.1 ± 0.1 | | | 8 ± 1 | 8 ± 2 | | 30.9 ± 10.9 ^d | 30.9 ± 10.9 ^d |
| SO ₂ (ppm) | | | | | | | 13.1 ± 3.6 ^d | 13.1 ± 3.6 ^d |
| SO ₄ ⁻² (μg/m ³) | | | | | | | | |
| O ₂ (%) | | | | | | | | |
| Aliphatic aldehydes | | | | | | | | |
| Formaldehyde (ppm) | | | | | | | | |
| Acrolein (ppm) | | | | | | | | |
| NH ₄ ⁺ | | | | | | | | |
| Hydrocarbons (ppm) | | | | 18.9 ± 4.1 ^e | 18.8 ± 4.1 ^e | | | |
| PAHs Benzo(a)pyrene | | | | | | | | |
| Nitropyrene | | | | | | | | |

^a All ± are S.D. unless specified otherwise.

^b Mass median diameter.

^c Geometric standard deviation.

^d Samples from dilution tunnel, exposure chamber reported to have approximately the same concentrations.

^e Data from first year of study (Bernstein et al., 1984).

APPENDIX A. EXPERIMENTAL PROTOCOL AND COMPOSITION OF EXPOSURE ATMOSPHERES^a

| | | | |
|---|--|----------------|---------------------|
| Facility/Sponsor | Battelle, Pacific Northwest Laboratory | | |
| Reference | Karagianes et al., 1981 | | |
| Engine type | 43 bhp, 3 cylinder | | |
| Operating mode | Simulated mining cycle | | |
| Fuel type | Equivalent to VV-F-800 A grade DF-2 | | |
| Fuel sulfur | - | | |
| Exposure regime | 6 h/d, 5 d/week, 87 weeks | | |
| Exposure conditions | Control | Exhaust | Exhaust + coal dust |
| Particle conc. (mg/m ³) | - | 8.3 ± 2.0 | 13.5 ± 4.0 |
| Resp. particles (mg/m ³) | | 95% respirable | |
| Particle size (μm) MMD ^b (GSD) ^c | | 0.71 (2.3) | |
| CO ₂ (%) | | | |
| CO (ppm) | | 50 ± 3 | |
| NO ₂ (ppm) | | 4-6 | |
| NO (ppm) | | | |
| NO _x (ppm) | | | |
| SO ₂ (ppm) | | <1 | |
| SO ₄ ⁻² (μg/m ³) | | | |
| O ₂ (%) | | | |
| Aliphatic aldehydes (ppm) | | <1 | |
| Formaldehyde (ppm) | | | |
| Acrolein (ppm) | | | |
| Ammonia (ppm) | | 26-40 | |
| Hydrocarbons (ppm) | | | |
| <u>PAHs</u> Benzo(a)pyrene | | | |
| Nitropyrene | | | |

^a All ± are S.D. unless specified otherwise.

^b Mass median diameter.

^c Geometric standard deviation.

APPENDIX A. EXPERIMENTAL PROTOCOL AND COMPOSITION OF EXPOSURE ATMOSPHERES

| | | | | | | | | |
|--|-----------------------------------|------------|------------|---|--|------------------|------------------|------------------|
| Facility/Sponsor | University of Pittsburgh | | | National Board of Occupational Safety and Health - Sweden | Ministry of Supply Chemical Defense Experimental Establishment | | | |
| Reference | Battigelli, 1965 | | | Ulfvarson et al., 1987 | Pattle et al., 1957 | | | |
| Engine type | 7 hp, four cycle, single cylinder | | | 1980 Volvo, 6 cylinder | 0.568 L, single cylinder | | | |
| Operating mode | | | | 2,500 rpm | 1,600 rpm; A - no load; B - load; C - load plus worn injector; D - no load, high fuel-air ratio. | | | |
| Fuel type | | | | | 47 cetane | | | |
| Fuel sulfur | | | | | 0.51% | | | |
| Exposure regime | 15-60 min | | | 3 h, 40 min | 5 h | | | |
| Exposure conditions | Dilution A | Dilution B | Dilution C | Exhaust | A | B | C | D |
| Particle conc. (mg/m ³) | | | | 0.6 | 74 | 122 | 53 | 1,070 |
| Particle size (μm) | | | | | | | | |
| CO ₂ (%) | 0.1 | 0.9 | 1.1 | | | | | |
| CO (ppm) | <20 | 30 | 55 | 4.63 | 560 | 410 | 380 | 1,700 |
| NO ₂ (ppm) | 1.3 | 2.8 | 4.2 | 2.07 | 23 | 51 | 43 | 12 |
| NO (ppm) | | | | 4.56 | | | | |
| NO _x (ppm) | | | | | 46 | 209 | 174 | 44 |
| SO ₂ (ppm) | 0.2 | 0.5 | 1 | | | | | |
| SO ₄ ⁻² (μg/m ³) | | | | | | | | |
| O ₂ (%) | 20.5 | 20.0 | 19.5 | | | | | |
| Aliphatic aldehydes | <1.0 | <1-2 | 1-2 | | 16 ^b | 6.0 ^b | 6.4 ^b | 154 ^b |
| Formaldehyde (ppm) | <0.1 | <0.1 | <0.1 | 0.04 | | | | |
| Acetaldehyde | | | | 0.17 | | | | |
| Acrolein (ppm) | <0.05 | <0.05 | <0.05 | | | | | |
| NH ₄ ⁺ | | | | | | | | |
| Hydrocarbons (ppm) | <2.0 | 2.5 | 3.2 | | | | | |
| Benzene (ppm) | | | | 0.06 | | | | |
| Toluene (ppm) | | | | 0.35 | | | | |
| PAHs (μg/m ³): Benzo(a)pyrene | | | | 640 | | | | |
| Nitropyrene | | | | | | | | |

^a All ± are S.D. unless specified otherwise.

^b As formaldehyde.

APPENDIX A. EXPERIMENTAL PROTOCOL AND COMPOSITION OF EXPOSURE ATMOSPHERES

| | | | | | | | |
|---|--|-------------------------------------|---------------------------------|--|--|--|-----------------|
| Facility/Sponsor | U.S. Environmental Protection Agency | | | | | | |
| Reference | Gillespie, 1980; Hyde et al., 1980; Malanchuk, 1980; Orthoefer, 1980; Stara et al., 1980 | | | | | | |
| Engine type | Automobile gasoline engine | | | | | | |
| Operating mode | Urban cycle | | | | | | |
| Fuel type | | | | | | | |
| Fuel sulfur | | | | | | | |
| Exposure regime | 16 h/d, 7 d/week, 68 mo. | | | | | | |
| Exposure conditions | Control | Non-irradiated gasoline exhaust (R) | Irradiated gasoline exhaust (I) | SO ₂ + H ₂ SO ₄ | R + SO ₂ + H ₂ SO ₄ | I + SO ₂ + H ₂ SO ₄ | Nitrogen oxides |
| Particle conc. (mg/m ³) | | | | | | | |
| Particle size (μm) | | | | | | | |
| CO ₂ (%) | | | | | | | |
| CO (ppm) | 4.9 | 97.5 ± 10.0 | 94.5 ± 19.6 | - | 98.4 ± 13.8 | - | - |
| NO ₂ (ppm) | 0.04 | 0.05 ± 0.02 | 0.94 ± 0.36 | - | 0.05 ± 0.03 | 0.89 ± 0.36 | 0.64 ± 0.12 |
| NO (ppm) | 0.04 | 1.45 ± 0.42 | 0.19 ± 0.29 | - | 1.51 ± 0.44 | 0.19 ± 0.29 | 0.25 ± 0.06 |
| NO _x (ppm) | | | | | | | |
| SO ₂ (ppm) | 0.03 | - | - | 0.42 ± 0.22 | 0.48 ± 0.23 | 0.42 ± 0.21 | - |
| H ₂ SO ₄ (ppm) | - | - | - | 0.02 ± 0.01 | 0.02 ± 0.01 | 0.03 ± 0.01 | - |
| Oxidants (ppm as O ₃) | 0.02 | - | 0.20 ± 0.09 | - | - | 0.20 ± 0.08 | - |
| Aliphatic aldehydes | | | | | | | |
| Formaldehyde (ppm) | | | | | | | |
| Acrolein (ppm) | | | | | | | |
| NH ₄ ⁺ | | | | | | | |
| Hydrocarbons (ppm as CH ₄) | 2.7 | 27.5 ± 4.4 | 23.9 ± 6.1 | - | 27.4 ± 4.3 | 23.9 ± 6.0 | - |
| PAHs Benzo(a)pyrene | | | | | | | |
| Nitropyrene | | | | | | | |

^a All ± are S.D. unless specified otherwise.